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TRENDS IN THE MERCURY CONTENT OF WESTERN LAKE ERIE FISH AND SEDIMENT 1970-1977

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Ontario
Ministry of the Environment

The Honourable
George R. McCague,
Minister

K.H. Sharpe,
Deputy Minister

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1. WATER QUALITY - REG - CAN - ONT - LAKE ERIE
2 SEDIMENT QUALITY
3 POLLUTION - MERCURY

TRENDS IN THE MERCURY CONTENT OF WESTERN LAKE ERIE FISH AND SEDIMENT 1970-1977

prepared by
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INTRODUCTION

Investigations by the Ontario Water Resources Commission in 1970 revealed high levels of mercury in some fish species and in sediments of Western Lake Erie. The occurrence of high mercury levels in the western basin sediments and fish is attributed to past discharges from the Dow Chemical of Canada Limited plant at Sarnia, Ontario and BASF Wyandotte Chemical Limited plant at Wyandotte, Michigan. The commercial walleye and white bass fisheries were subsequently closed by the province in June 1970. This followed the March closure of the Lake St. Clair fishery for all species.

Further investigations by the Ministry and other agencies indicate that significant decreases in mercury levels in fish (1) and sediments of Lake St. Clair (2) have taken place during the period 1970-75 subsequent to the curtailment of mercury losses from the chlor-alkali plants.

The mercury content of fish from the western basin of Lake Erie also declined to levels where commercial catches of walleye and white bass were allowed to resume in 1975 subject to length limitations. Continued mercury testing by the Fisheries and Marine Service of the Department of Fisheries and Environment have indicated that walleye up to 19" in length and white bass up to 13" in length may currently (1977) be marketed (3), i.e. fish not exceeding these lengths could be expected to meet the Department of National Health and Welfare guideline of 0.5 ppm for safe human consumption.

This report examines trends of mercury levels in these two fish species since 1971 and compares these trends with changes in mercury concentrations in Western Lake Erie sediments from 1970 to 1976. It was felt that such a comparison would provide insight into the role of deposited mercury in affecting the levels found in fish.

STUDY OUTLINE

Fisheries and Marine Service data on the mercury content of the western basin walleye and white bass (edible portion) were obtained from the Ontario Ministry of Natural Resources.

In 1976, samples of surficial sediment were collected from 53 locations on a rectangular grid (Figure 1) compared to the 34 locations sampled in 1970 (Figure 2). In both years, two Shipek dredge samples were taken at each location and a composite of equal amounts of the top 3 cm of sediment was submitted as one sample. Total mercury analyses were carried out according to methods reported by Bishop et al (4).

RESULTS

A. MERCURY IN FISH

Table 1 shows the results of mercury testing of walleye and white bass from 1971 to 1977. While there is an apparent decline in mercury levels since 1971, the actual trend is obscured in the comparison of yearly means for fish of considerably different sizes. The mean concentration in fish of selected lengths was estimated for each year using the geometric regressions of concentration versus length provided with the Fisheries and Marine Service data. The decline in mercury content was then expressed by the exponential curves shown in Figures 3 and 4. The curves indicate that the mercury level in a walleye of 50 cm length has decreased from 1 ppm in 1970 to 0.52 in 1976. Also, a white bass of 35 cm length approached the federal guideline in 1976. This rate of decline compares favourably with that found for Lake St. Clair fish (1).

B. MERCURY IN SEDIMENTS

The mercury concentrations found at each station in 1970 and 1976 are shown in Tables 2 and 3 and the distribution of mercury in the western basin for each year is presented in Figures 5 and 6.

In both years, higher levels of mercury occurred in the deeper, central part of the basin in a fanwise distribution emanating from the Detroit River mouth. This pattern conforms to that found by Thomas and Jaquet (5) and Walters et al (6). A comparison of levels found by MOE in 1970 and by the above authors in 1971 shows good agreement (Table 4).

The MOE 1976 data reveal a slight decrease (not significant at a 90% confidence level) in the mean concentration over the sampling area and a narrower range in concentration when compared to the earlier data. Mercury levels in 1976 exhibited an almost normal distribution (Figure 7) compared to a heavily-skewed distribution existing in 1970 (Figure 8), due mainly to the continual material resuspension and deposition of surface sediments in the shallow western basin.

DISCUSSION

The results indicate a far more significant decline of mercury levels in western basin fish than in sediments since controls were instituted on mercury losses from upstream industrial sources. Even larger walleye (40-50 cm) now exhibit mercury levels within the federal guideline for human consumption in spite of total mercury levels in sediments which have not appreciably changed over the same period of time.

The fact that the mean concentration of mercury in the basin sediments has not decreased significantly can be attributed to the continuing input of mercury to Lake Erie from Lake St. Clair, which has compensated for some transport of mercury out of the western basin to the central basin of the lake. Thomas et al (2) estimated that the mercury transported with suspended sediment from Lake St. Clair to Lake Erie amounted to somewhere between 4 and 13 metric tonnes over the period 1970 to 1974. As the mercury content of Lake St. Clair sediments is gradually declining, the amount of mercury being transported to Lake Erie will decrease and the mean concentration in the western basin should also decline.

Jernelov (7), Hasselrot and Gothberg (8), DeFreitas et al (9) and others demonstrated through laboratory and field experiments that mercury uptake occurs both from water and through the food chain. Additionally, they investigated the relative importance of these pathways in accounting for tissue mercury levels and found that factors such as fish species, growth rate, body size and water temperature affect and control the uptake processes. Jernelov (7) also indicated that "food contributes to concentrations of mercury in fish in such a way that it provides a basic level above which the fish continue to accumulate mercury from the water directly".

In the western basin of Lake Erie, as in the St. Clair system, the availability of mercury in the water column must have diminished significantly following curtailment of the industrial inputs as these had been primarily in the form of finely divided colloidal suspensions (10). Mercury present in the water column now would therefore result mainly from the resuspension of or methylation from sedimented material. In this regard, Spangler et al (11) found from studies in the delta area of Lake St. Clair, that demethylation processes are active in counteracting the release of methylmercury from sediment.

Because of the significant decline in mercury available for direct uptake it is reasonable to assume that levels in fish should decline but that this decline could be limited by continuing uptake through the food chain. However, since mercury levels in all the fish species sampled in the area are declining it follows that the contribution from food sources especially for top line predators such as walleye is also diminishing.

CONCLUSION

The mercury content of walleye and white bass from Western Lake Erie has declined significantly since 1971 in response to controls on upstream industrial sources. At the same time the average mercury concentration of western basin sediments has not changed appreciably. It appears therefore that release of mercury from sediments is not affecting the return to acceptable levels in fish.

Routine monitoring of mercury levels in fish, coupled with a periodic assessment of sediment levels should be continued to follow the rate of recovery.

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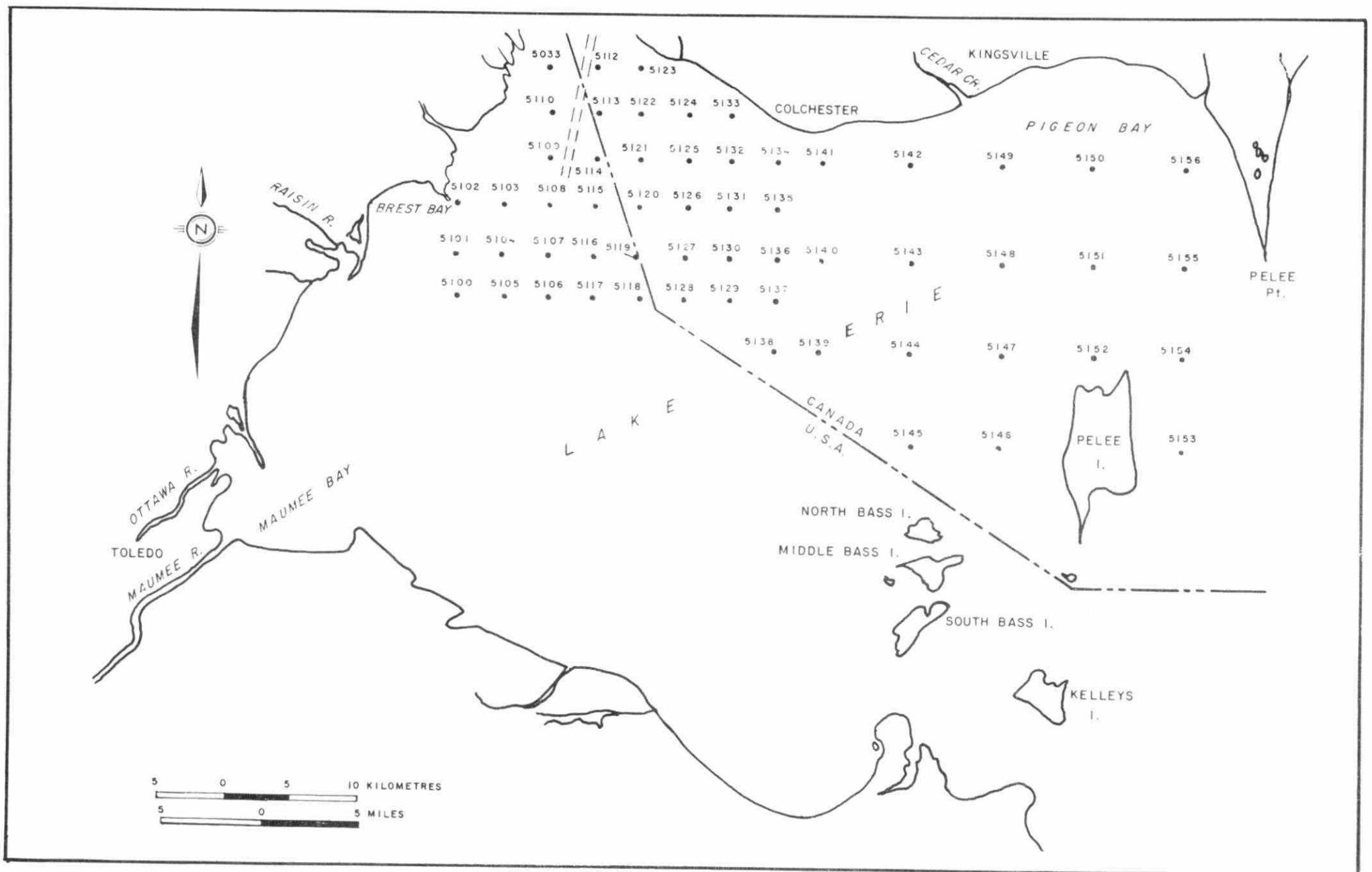

FIGURE 1 : SEDIMENT SAMPLING LOCATIONS MERCURY SURVEY **1976**

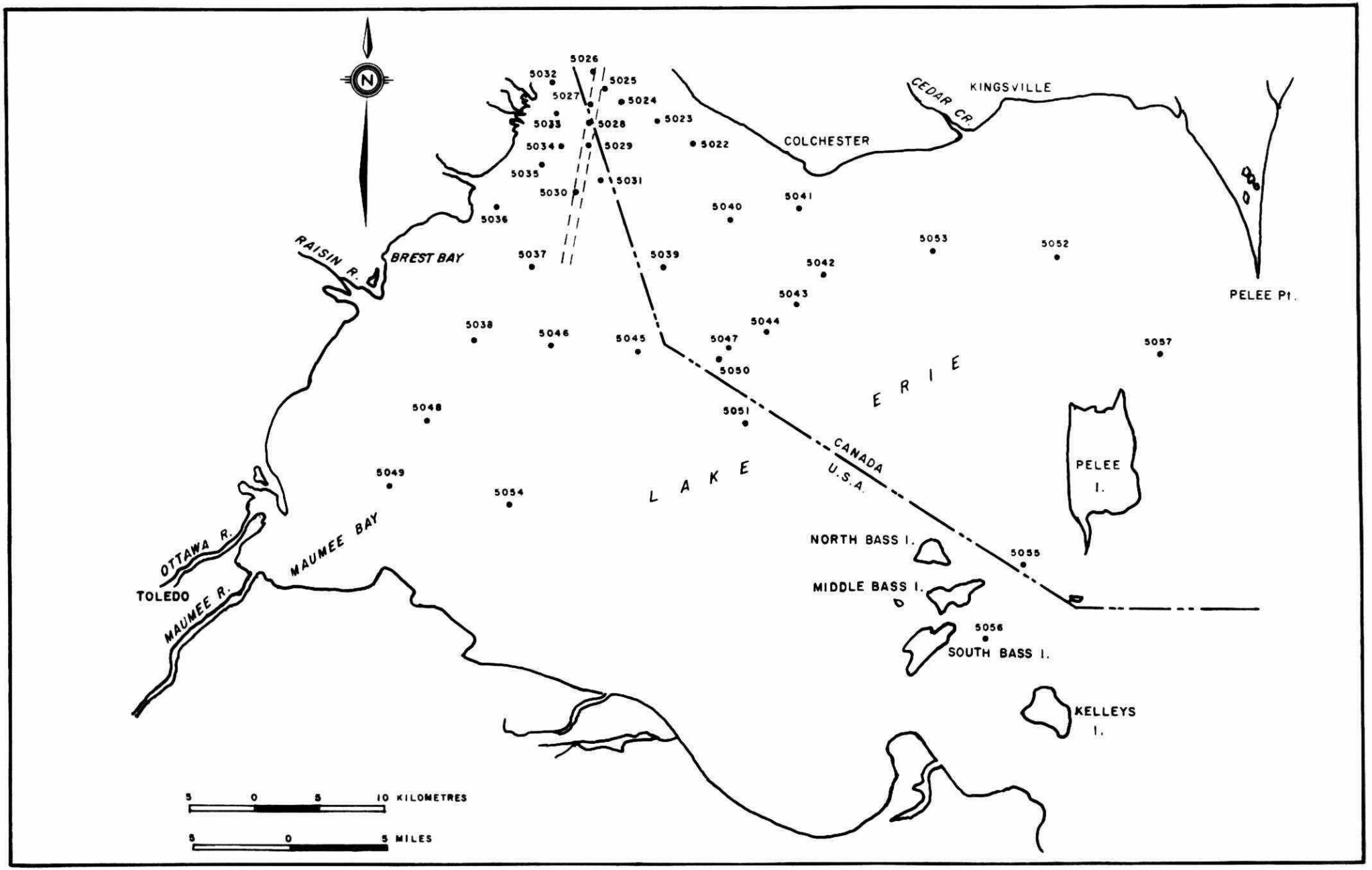

FIGURE 2: SEDIMENT SAMPLING LOCATIONS MERCURY SURVEY **1970**

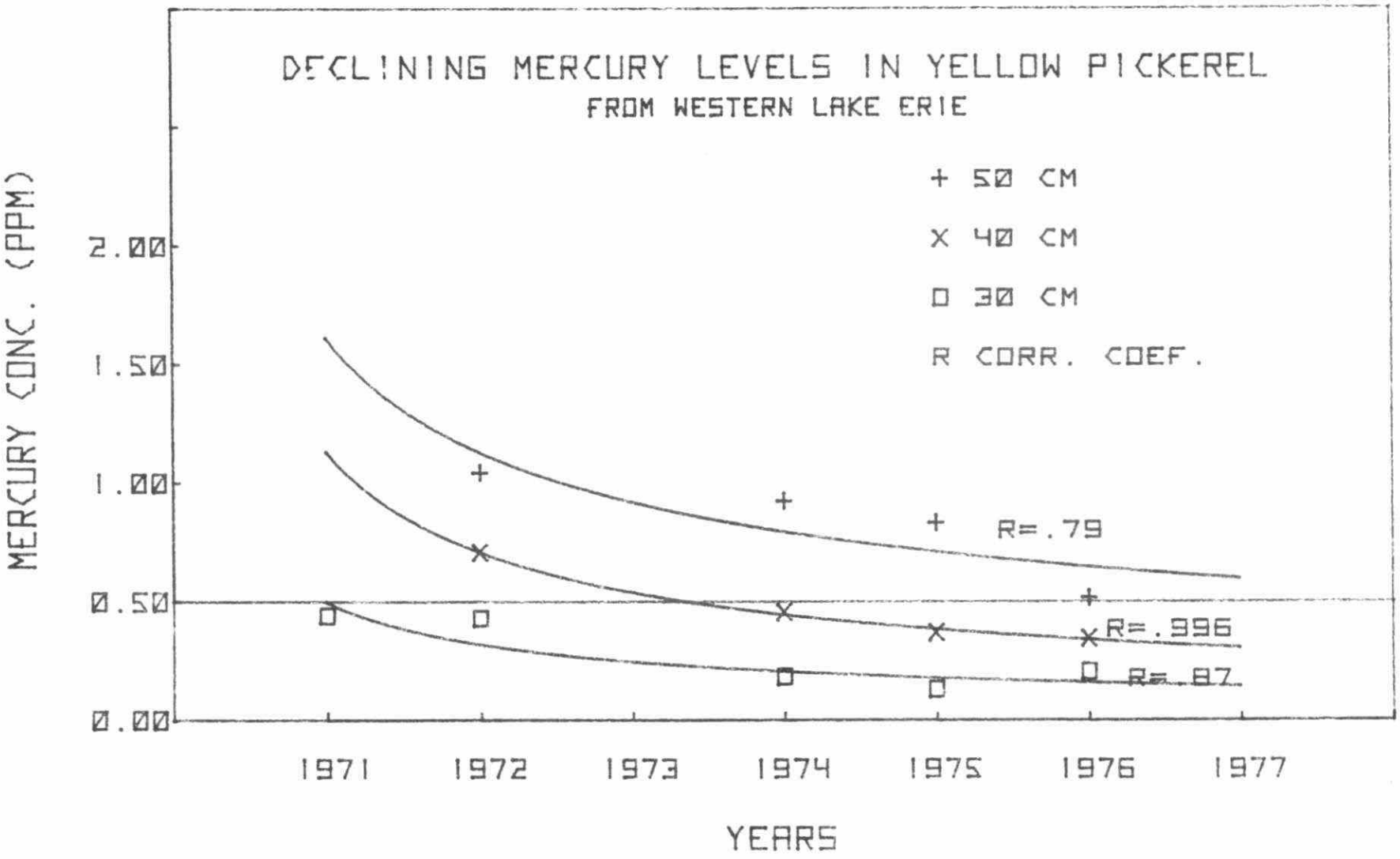
DECLINING MERCURY LEVELS IN YELLOW PICKEREL
FROM WESTERN LAKE ERIE
+ 50 CM
X 40 CM
□ 30 CM
R CORR. COEF.
MERCURY CONC. (PPM)
2.00
1.50
1.00
0.50
0.00
R=.79
R=.996
R=.87
1971
1972
1973
1974
1975
1976
1977
YEARS

FIGURE 3

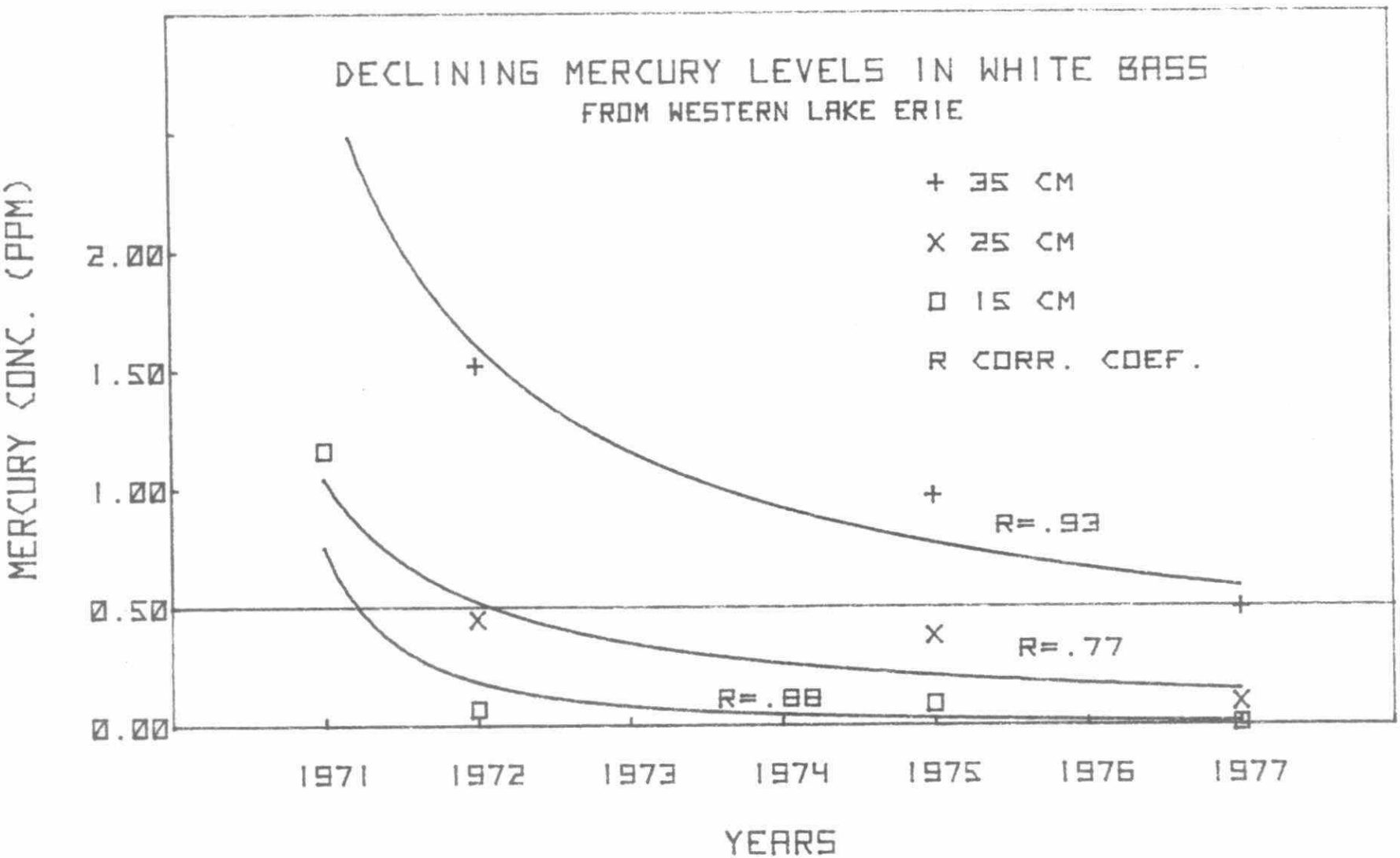
DECLINING MERCURY LEVELS IN WHITE BASS
FROM WESTERN LAKE ERIE
+ 35 CM
X 25 CM
□ 15 CM
R CORR. COEF.
R=.93
R=.77
R=.88
MERCURY CONC. (PPM)
2.00
1.50
1.00
0.50
0.00
1971
1972
1973
1974
1975
1976
1977
YEARS

FIGURE 4

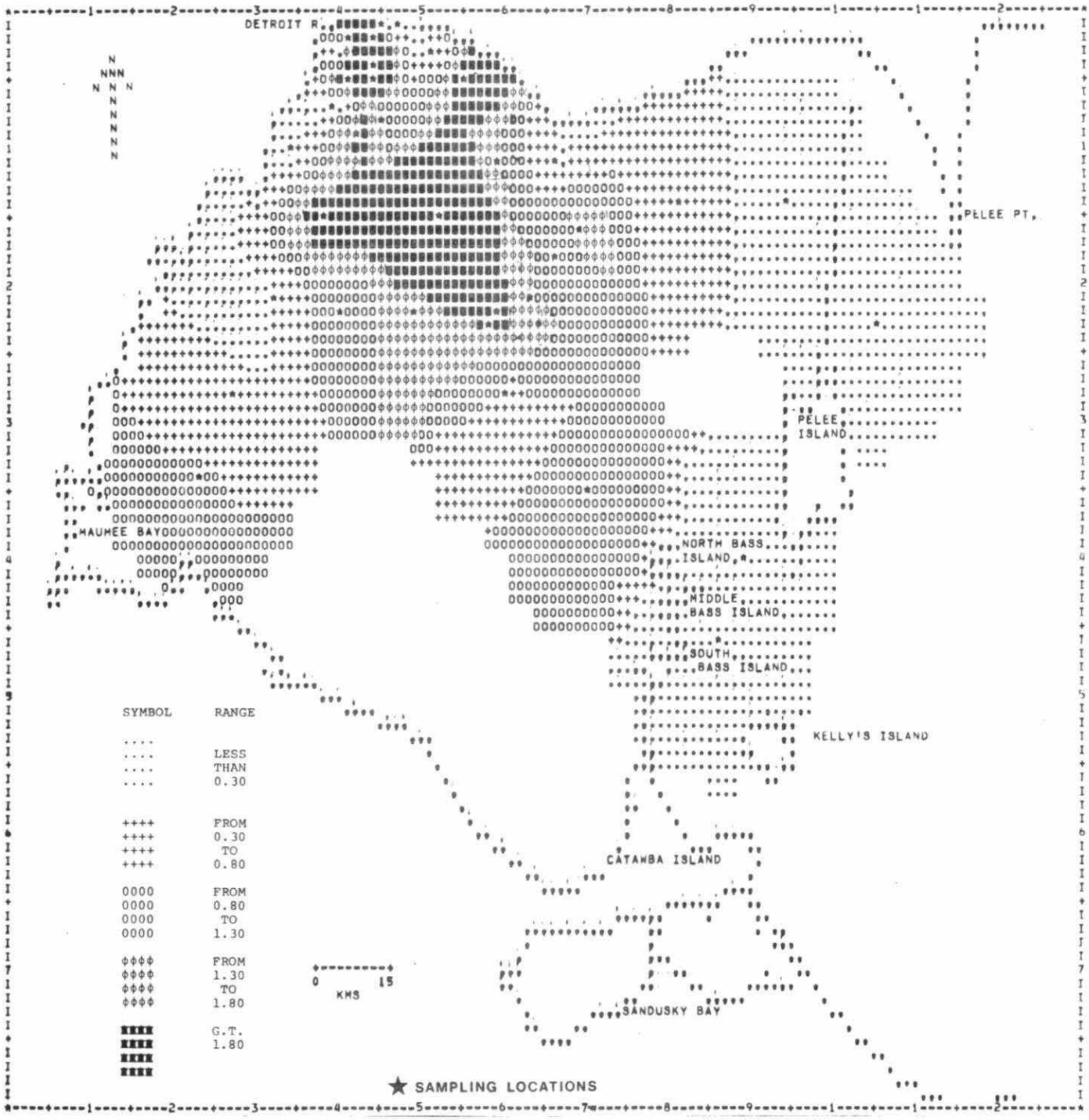

FIGURE 5 MERCURY DISTRIBUTION IN SEDIMENTS (0-3 cm.) WESTERN BASIN OF LAKE ERIE, 1970.

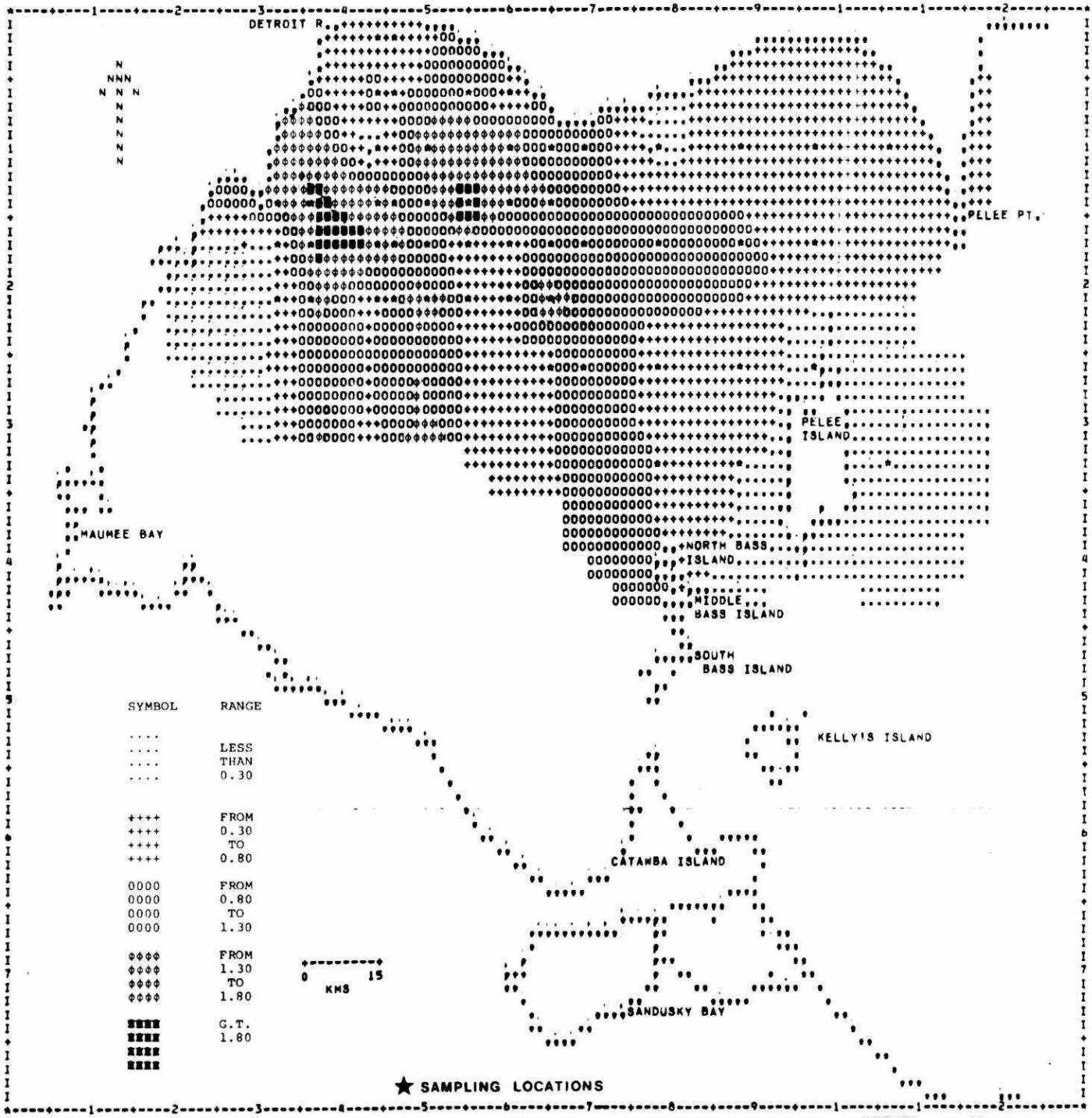

FIGURE 6 MERCURY DISTRIBUTION IN SEDIMENTS (0-3 cm.) WESTERN BASIN OF LAKE ERIE, 1976.

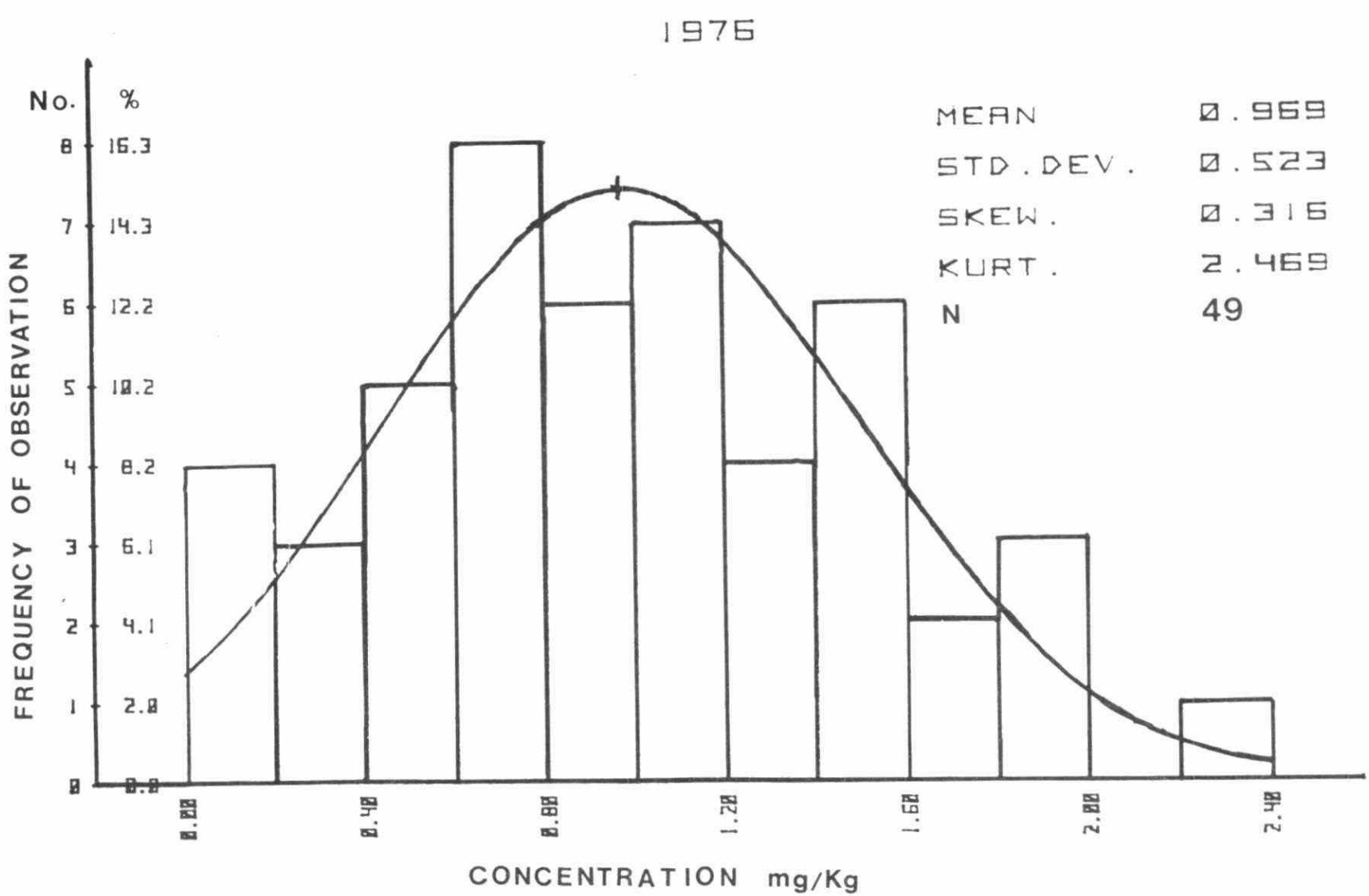

FIGURE 7 : FREQUENCY DISTRIBUTION OF MERCURY SURFICIAL SEDIMENTS 1976

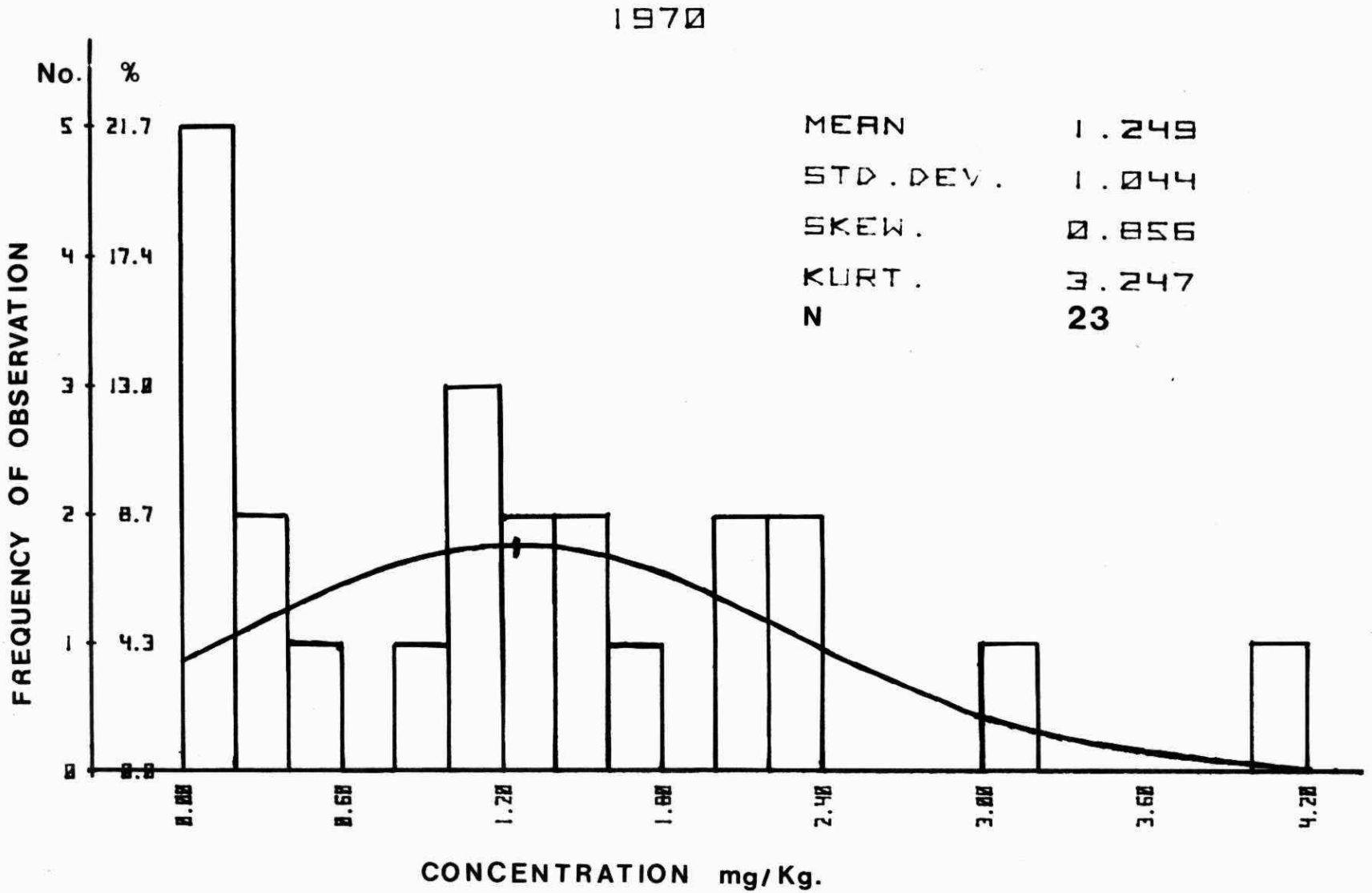

FIGURE 8 : FREQUENCY DISTRIBUTION OF MERCURY SURFICIAL SEDIMENTS 1970

TABLE 1

(a) Walleye

Year	N	Mean ppm	Range ppm	% over 0.5 ppm	Mean Length (cm)	Mean Weight (gm)
1971	7	0.55	0.4-0.94	57	26	148
1972	101	0.58	0.14-1.35	76	34	426
1974	50	0.52	0.20-1.06	48	40	831
1975	72	0.68	0.15-1.98	51	45	NA
1976	192	0.31	0.09-1.25	8	35	447
1977	-	-	-	-	-	-

(b) White Bass

Year	N	Mean ppm	Range ppm	% over 0.5 ppm	Mean Length (cm)	Mean Weight (gm)
1971	12	1.19	0.49-2.12	92	20	178
1972	149	0.53	0.08-1.96	34	24	200
1974	-	-	-	-	-	-
1975	61	0.77	0.12-1.57	85	31	457
1976	2	0.31	0.26-0.37	-	28	380
1977	92	0.21	0.06-1.06	5	28	316

(c) Regression with Fish Lengths

	Walleye			White Bass		
Year	Intcpt*	Slope	Corr*	Intcpt*	Slope	Corr*
1971	1.4156	-1.20	-0.19	0.3476	-0.24	-0.11
1972	-2.9378	1.74	0.74	-5.4383	3.64	0.84
1974	-5.4201	3.17	0.79	-	-	-
1975	-6.2644	3.64	0.74	-4.3214	2.79	0.72
1976	-3.3623	1.81	0.74	-	-	-
1977	-	-	-	-7.7329	4.81	0.79

*Denotes Log Transformed Values.

TABLE 2

Mercury in Surficial Sediments of
Western Basin of Lake Erie

(July 7-9, 1976)

Stn. Number	Stn. Depth (m)	Hg (mg/kg)	Sediment Description
5112	5.0	0.48	Grey silt with small shells and worms
5113	7.0	0.73	Grey silt
5115	8.5	1.30	Grey silt with small shells
5116	10.5	1.12	Grey silt-small clams
5117	11.0	1.47	Grey silt with small worm and clams
5106	10.5	0.39	Grey silt and clams
5105	9.0	1.39	Grey silt with clams and snails
5100	8.5	0.16	Black sand and silt with clams and snails
5101	7.5	0.07	Grey brown sand with snails
5102	7.5	1.37	Grey-black silt and some sand
5103	9.0	1.90	Grey-black silt
5104	9.0	1.92	Grey-black silt
5107	10.0	1.95	Grey-black silt with small snails
5108	9.0	1.61	Grey-black silt
5109	6.0	0.13	Grey sand with small snails
5110	5.5	0.87	Silt grey black
5033	3.5	0.30	Black grey sand
5124	5.0	0.81	Black-grey silt with small stones
5121	9.0	1.43	Black grey silt
5120	9.0	1.18	Grey black silt
5119	10.0	.88	Grey black silt
5118	11.0	1.50	Grey black silt
5128	11.0	0.49	Grey black silt with small shell
5127	11.0	0.58	Grey black silt
5126	10.0	2.30	Grey black silt with clams
5125	9 5	1.50	Grey black silt
5124	9.0	1.50	Grey black silt with clams
5133	9.0	0.68	Grey black silt with clams and wood
5132	10.5	1.40	Grey black silt
5131	11.0	1.40	Grey black silt with small shells
5130	11.5	0.61	Grey black silt with small shells & stones
5129	11.5	.65	Grey black clay and silt
5138	12.0	.67	Black grey silt and clay
5137	11.5	1.60	Grey black silt and clay with small worms
5136	11.5	1.0	Grey black silt with clams
5135	11.5	1.30	Grey black silt with small shells
5134	10.5	1.10	Grey black silt with small shells and pieces of wood
5141	10.5	1.10	Grey black silt with small shells
5140	12.0	0.89	Grey black silt and clay
5139	11.5	1.10	Grey black silt with clay
5144	12.0	0.72	Grey black silt and clay
5145	12.0	0.80	Grey black silt and clay with small shells
5146	10.5	.30	Grey black silt and clay with small stones
5150	12.5	.55	Brown grey silt and clay
5156	12.0	.62	Grey black silt

Stn. Number	Stn. Depth (m)	Hg (mg/kg)	Sediment Description
5151	12.0	.57	Grey black silt and clay with small shell
5152	11.0	.07	Hard sand-brown
5153	11.0	0.02	Sand and gravel
5149	12.0	.56	Grey and black silt and clay
5147	12.0	.63	Grey black silt and clay
5148	13.0	.88	Grey black silt with small worms
5143	12.5	1.09	Grey black silt and clay
5142	11.0	.23	Grey black silt and clay with small worms

REMARK: Al samples are composited of 2 casts.

TABLE 3

Mercury in Surficial Sediments of the Western Basin of Lake Erie

May 1970

Station Number	Station Depth (m)	T.Hg Conc. (mg/kg)	Station Number	Station Depth (m)	T.Hg Conc. (mg/kg)
5022	7.3	2.30	5040	9.7	1.23
5023	5.2	0.27	5041	10.3	0.27
5024	4.2	0.13	5042	10.9	1.51
5025	5.8	0.24	5043	11.3	1.03
5026	10.3	3.20	5044	10.9	1.34
5027	10.3	3.60	5045	10.3	1.63
5028	4.6	4.60	5046	-	1.02
5029	6.4	1.50	5047	7.6	3.00
5030	9.4	2.10	5048	7.6	0.34
5031	11.6	1.04	5049	10.9	0.81
5032	4.2	2.20	5050	10.2	0.99
5033	2.4	0.06	5051	10.3	0.74
5034	4.2	2.20	5052	11.1	0.19
5035	3.0	0.17	5053	11.9	0.44
5036	7.0	0.15	5054	7.9	0.87
5037	8.5	2.10	5055	11.9	0.11
5038	8.5	0.25	5056	10.9	0.13
5039	10.6	4.10	5057	10.3	0.05

TABLE 4

Year	Mean* ± S.D. (Range)	N	Source	Remarks
1970	1.29±1.044 (0.05–4.6)	23	MOE (1970)	Excluding stations near the Detroit River mouth and Maumee Bay.
1971	1.217±0.792 (0.065–2.929)	53	Thomas and Jaquet (1976)	Western Basin and its inshore zone.
1971	0.88±0.883 (.020–4.0)	58	Walters et al (1974)	Level of 1.09 ± 1.08 and range .052-4.0 detected for a grid similar to that of MOE.
1976	0.969±0.523 (.02–2.3)	49	MOE	

*Levels - mg/kg dry weight basis.